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Mesh Selection Within the Cod-end of Trawls. The Effects of Narrowing the Cod-end and Shortening the Extension

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Introduction

A typical trawl gear consists of a net, spreading wires and otterboards as depicted in Figure 1. Fish are herded between the otterboards and along the spreading wires into the mouth of the trawl where they swim until exhausted. They then drift back through the funnel of the net, along the extension and into the cod-end. Selection is thought to take place mainly in the cod-end, where young haddock and whiting may be able to escape through the meshes. Underwater observations have shown that the

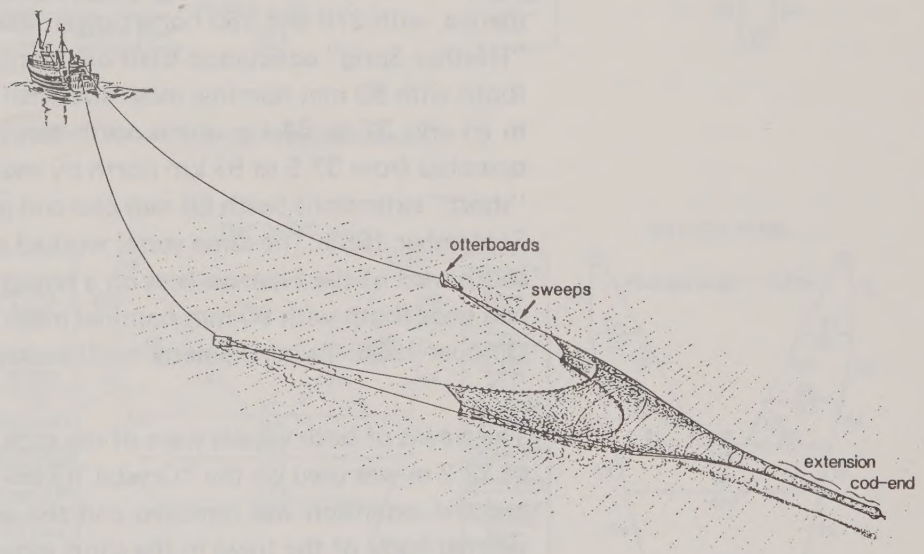


Figure 1. View of trawl gear showing otter boards, sweeps and net with extension and cod-end.

design of the cod-end has an effect on the mesh opening. A typical cod-end used by commercial vessels may have 120 meshes around its circumference. The meshes are almost completely closed at the forward end of the cod-end (Plate I). If the meshes round the cod-end are reduced to 60 (called a 'narrow' cod-end) the meshes open more to match the circumference of the extension (see Plate II). Differences in cod-end mesh opening

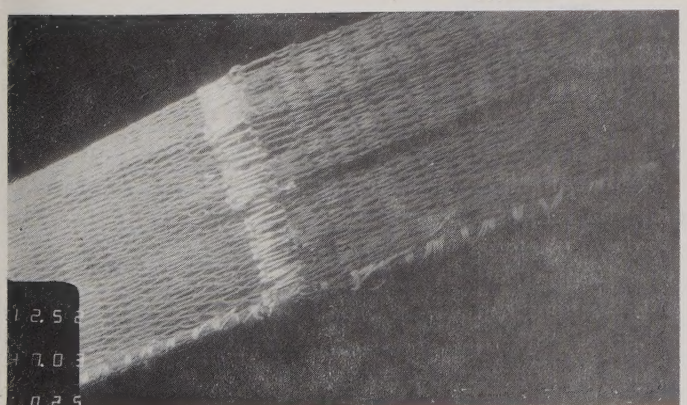


Plate I. The closed meshes at the forward end of a typical cod-end (right side) with 120 meshes round the circumference.

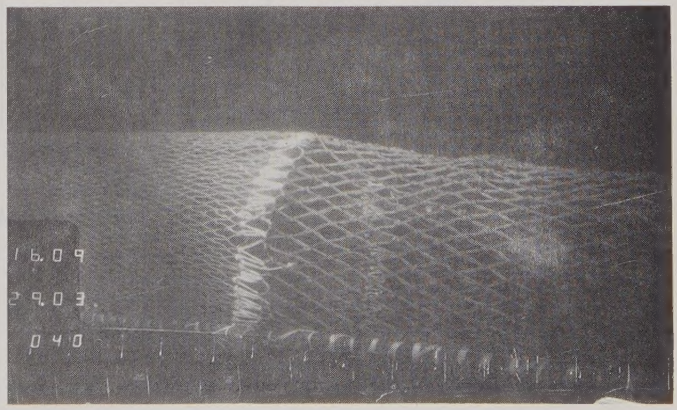


Plate II. The open meshes at the forward end of a cod-end with a reduced number of meshes (60) round the circumference.

are also observed when extension length is changed. Long extensions are typically used to lead the cod-end of the trawl from the aft part of the vessel, where the body of the trawl is stacked or rolled onto a net drum, onto the fore deck where the cod-end is unloaded. Long extensions create a narrow tube with closed meshes through which few fish can escape when the trawl is fishing. If no extension is included in the net and a normal cod-end having 120 meshes round is attached directly to the tapered body of the trawl, the cod end meshes open wider to match the larger circumference.

This report describes two experiments to measure the effect of these features on the selection characteristics of the cod-end. Results were obtained for haddock (*Melanogrammus aeglefinus* Linnaeus, 1758) and whiting (*Merlangius merlangus* Linnaeus, 1758) using the covered cod-end technique (described previously by Pope, Margetts, Hamley and Akyuz (1975)).

Materials and Methods

The experiments were conducted on two chartered commercial trawlers, "Heather Sprig" BCK 153 of 17 metres and "Crystal River" BCK 16 of 21 metres, with 270 and 550 horse power main propulsion units respectively. "Heather Sprig" conducted trials on "narrow" and "normal" cod-ends (both with 80 mm nominal mesh size with double twine) during June 1985 in an area 32 to 64 km north north-east of Peterhead "Crystal River" operated from 37.5 to 53 km north by east of Peterhead to test "long" and "short" extensions (with 80 mm cod-end mesh size with double twine) in September 1985. The same vessel worked on grounds up to 25 km south-west of the Flannan Isles on a repeat study of "narrow" and "normal" cod ends (both with 90 mm nominal mesh size with double twine) in October 1986. Twine diameter in all cod-ends was 3.5 mm.

The trawls of both vessels were of the rock hopper type. An extension length of 12.2 m was used on the "Crystal River" trawl for the long extension case and the extension was removed and the cod end attached directly to the tapered body of the trawl in the short extension case. The 12.2 m extension was also used by the "Crystal River" for the narrow and normal cod-end case. A 5.2 extension was used on "Heather Sprig" (see Figs. 2 and 3 for net construction details).

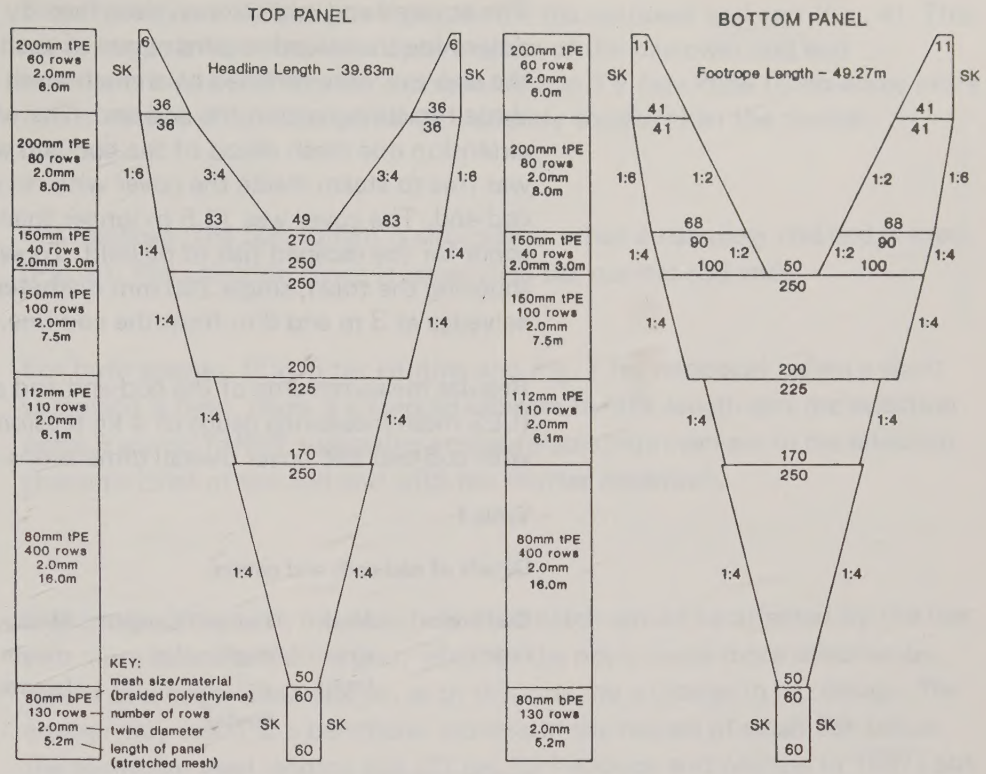


Figure 2. "Heather Sprig" demersal trawl.

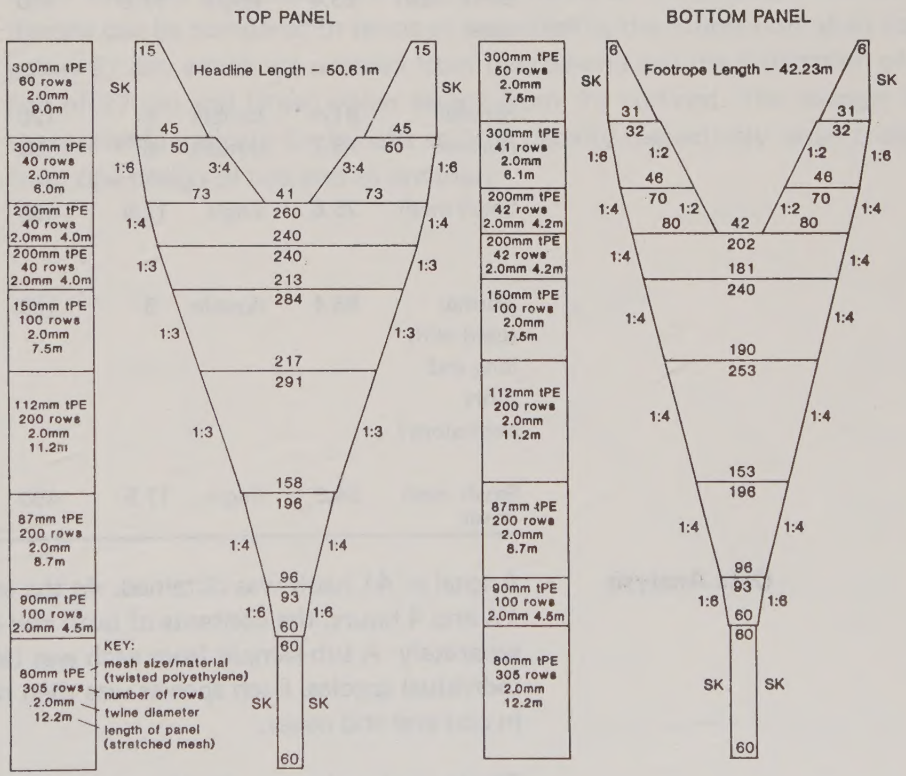


Figure 3. "Crystal River" demersal trawl.

The covered cod-end method described by Pope *et al.* (1975) was used to determine the selection parameters of each cod-end. Thus, fish escaping from the cod-end were retained by a small mesh covering bag, and compared with those remaining within the cod-end. The two panel cover was attached to the extension one mesh ahead of the cod-end and extension join. The cod-end was free to steam inside the cover with no attachments between cover and cod-end. The cover was 11.5 m longer than the cod-end to allow adequate room for the escaped fish to be held. To avoid twisting of the cover when shooting the trawl, single 200 mm diameter floats were attached to either selvedge at 3 m and 6 m from the cod-line.

Regular measurements of the cod-end and cover meshes were taken with an ICES mesh measuring gauge of 4 kg tension and these measurements along with cod-end and cover overall dimensions are given in Table I.

Table I

Details of cod-ends and covers

Cod-end type	Mesh size (mm)	Twine single or double	Length (m)	Meshes circum-ference	No. of times meshes measured (wet)	Total no. of meshes measured	Boat used on
Normal	87.3	double	6	120	3	545	"Crystal River" Sept 1986
Narrow	89.5	double	6	60	2	386	
Small mesh cover	23.4	single	17.5	450	1	26	
Normal	81.4	double	6	120	3	537	"Heather Sprig" June 1985
Narrow	78.7	double	6	60	2	257	
Small mesh	25.6	single	17.5	450	1	50	
Normal (used with long and short extensions)	83.4	double	6	120	4	718	"Crystal River" Sept 1985
Small mesh cover	24.6	single	17.5	450	1	164	

Data Analysis

A total of 41 hauls was obtained. At the end of each haul, lasting between 1½ and 4 hours, the contents of both cod-end and cover were measured separately. A sub-sample from each was taken, sorted and measured as individual species. Each species was then raised to the total numbers caught in cod-end and cover.

The separate selection data from each haul were combined to derive a single selection curve for each net on each species. The percentage of the catch in the cod-end was plotted against fish length in each cod-end (Figs. 4–7). The maximum likelihood logistic function was used to give a symmetric curve (Holden, 1971). The 50% length, selection factor and selection range (definitions of which are given in a footnote to Fig. 4) for each case are also shown. In addition Figures 8 to 11 contain the combined catch distribution for each species with each cod-end or extension type.

Selection Characteristics

Normal and Narrow Cod-ends

For whiting, the 50% length is greater for the narrower cod end (Fig. 4). This result suggests that the wider open meshes of the narrower cod end observed from a submersible and recorded on TV (see Plate II) do allow more fish to escape. The selection range is slightly smaller than the normal cod-end.

For haddock, the 50% length is also greater when a narrower cod-end is used (Fig. 5). The selection range is larger than the normal cod-end.

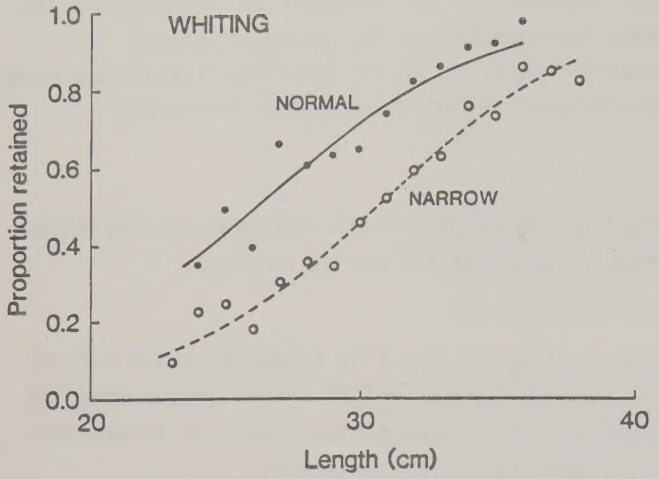
Long and Short Extensions

For both species, (Fig. 6 for whiting and Fig. 7 for haddock), when a short extension is used, there is a marked increase in 50% length and the selection range is almost halved, suggesting a considerable improvement in the selection characteristics of the cod-end with the shorter extension.

Catch Composition in the Cod-end

Fishermen often wish to know how their catch would be affected by the use of a more selective fishing gear, whether the net is made more selective by means of a larger mesh size or, as in this case, by a change in net design. The change may result in a beneficial increase in the release of small fish below the minimum legal landing size (27 cm for haddock and whiting in 1987) but at the same time it may cause a reduction in the catch of marketable fish.

From the data presented here the performance of the different cod-end designs can be compared in terms of two criteria, the proportion of all fish below 27 cm, which are released from the cod-end and the proportion of all fish of 27 cm and larger which escape from the cod-end. The changes in these criteria indicate the benefit and the penalty respectively when changing from one design of cod-end to another.

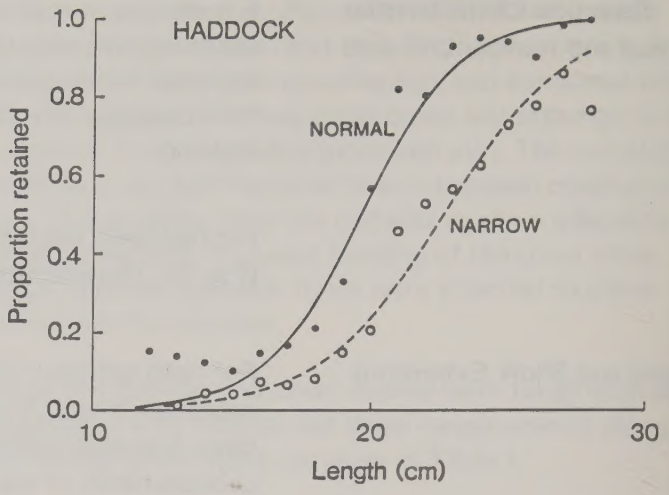


Haul	Cod-end Mesh Size (mm)	50% Length (cm)	Selection		Total No		No in Selection Range	
			Factor	Range (cm)	Cod-end	Cover	Cod-end	Cover
●	87.30	26.7±0.16	3.06	9.2	8,843	3,544	3,875	2,442
○	89.50	31.2±0.06	3.49	8.6	9,458	12,232	8,333	10,722

NOTE:

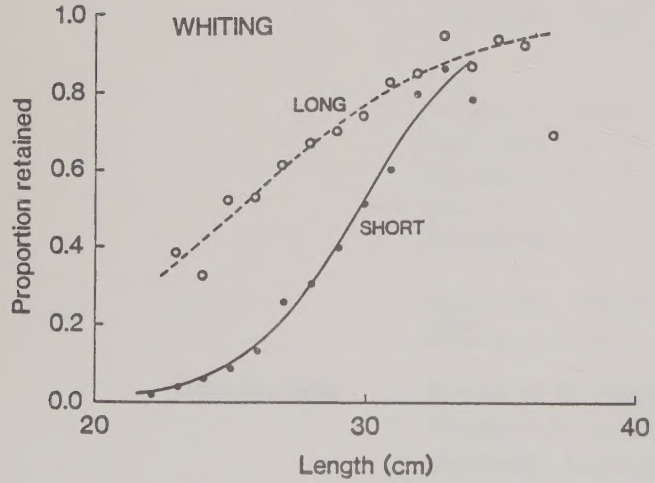
1. **The 50% retention length of a cod-end for a particular series is the fish length at which 50% of the species entering the cod-end is retained.**
2. **The selection range is the length difference between the 75% retention length and the 25% retention length.**
3. **The selection factor of a cod-end for a particular species is the ratio of the 50% retention length and the mean measured mesh size.**

Figure 4. Selection curves for whiting for normal and narrow cod-ends.



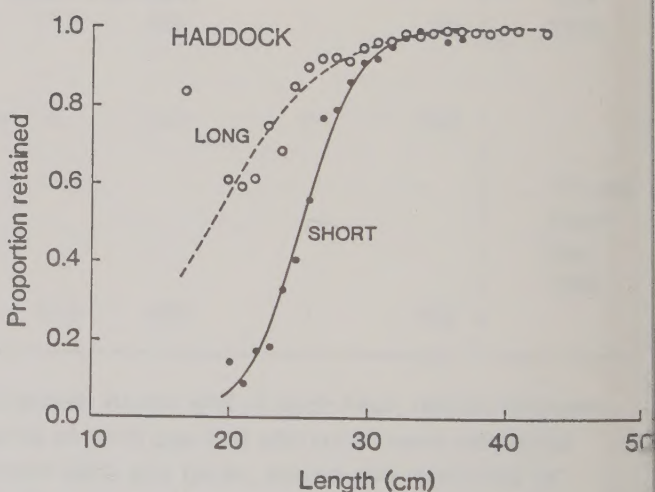
Haul	Cod-end Mesh Size (mm)	50% Length (cm)	Selection		Total No		No in Selection Range	
			Factor	Range (cm)	Cod-end	Cover	Cod-end	Cover
●	81.40	20.2±0.02	2.48	3.9	20,621	25,265	5,106	11,261
○	78.70	23.2±0.03	2.95	5.0	17,012	55,218	8,116	8,113

Figure 5. Selection curves for haddock for normal and narrow cod-ends.



Haul	Cod-end Mesh Size (mm)	50% Length (cm)	Selection		Total No		No in Selection Range	
			Factor	Range (cm)	Cod-end	Cover	Cod-end	Cover
●	83.40	30.3±0.08	3.63	4.7	2,496	9,319	1,507	2,572
○	83.40	25.9±0.15	3.11	8.7	5,331	2,568	3,015	2,016

Figure 6. Selection curves for whiting for long and short extensions.



Haul	Cod-end Mesh Size (mm)	50% Length (cm)	Selection		Total No		No in Selection Range	
			Factor	Range (cm)	Cod-end	Cover	Cod-end	Cover
●	83.40	26.0±0.05	3.11	4.6	11,765	5,856	1,789	2,391
○	83.40	19.4±0.27	2.33	8.7	28,777	1,633	516	331

Figure 7. Selection curves for haddock for long and short extensions.

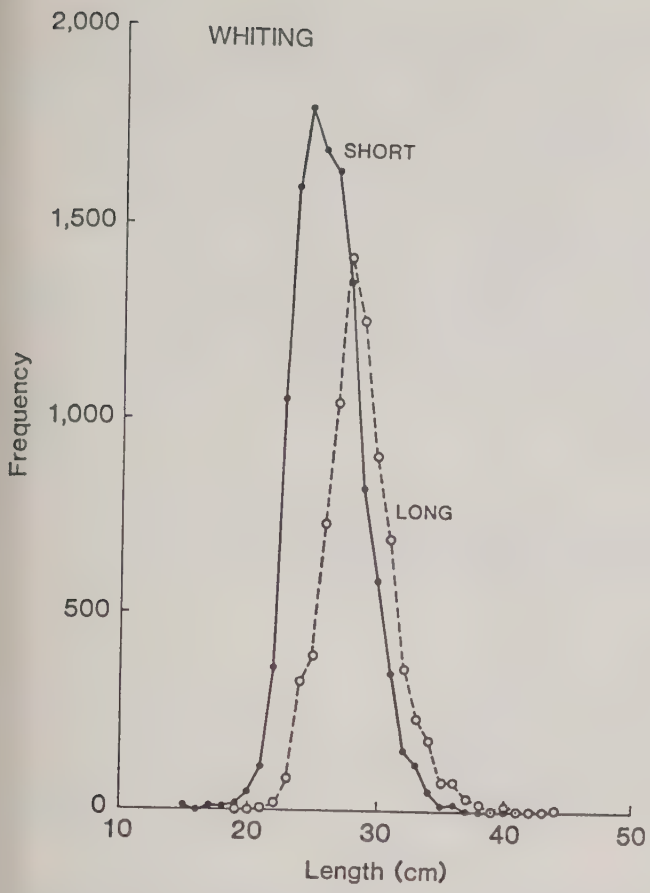


Figure 8. Whiting length/frequency distribution for long and short extensions.

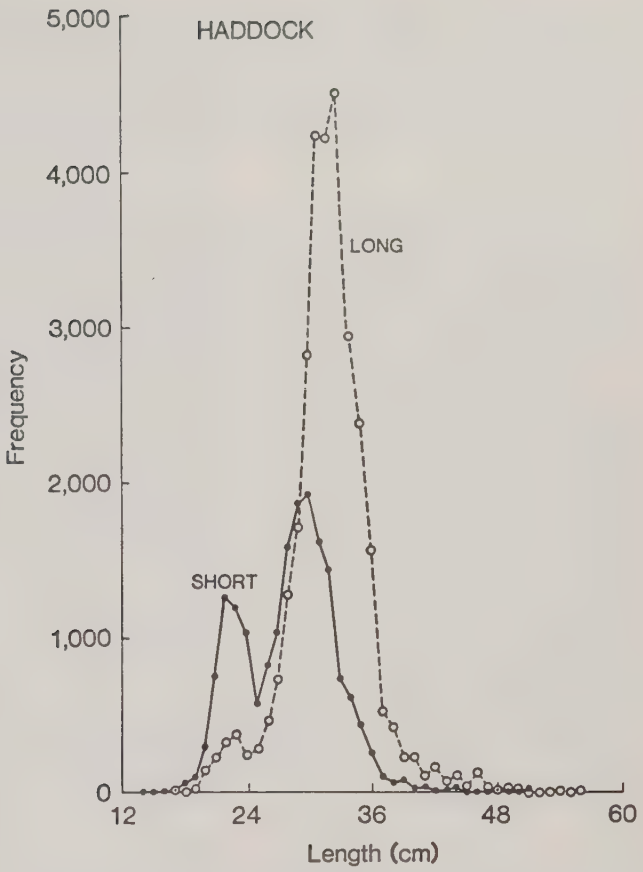


Figure 9. Haddock length/frequency distribution for long and short extensions.

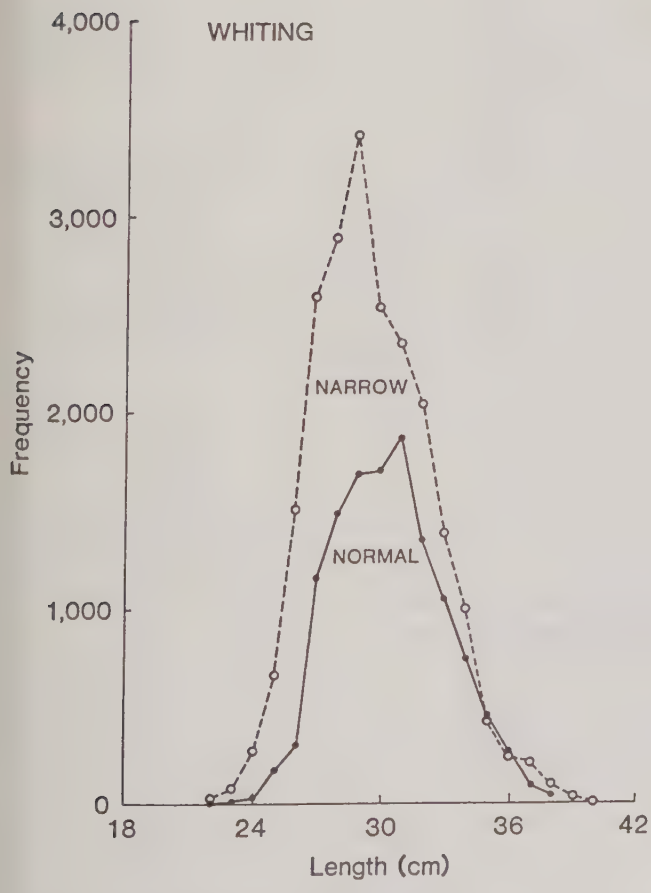


Figure 10. Whiting length/frequency distribution for normal and narrow cod-ends.

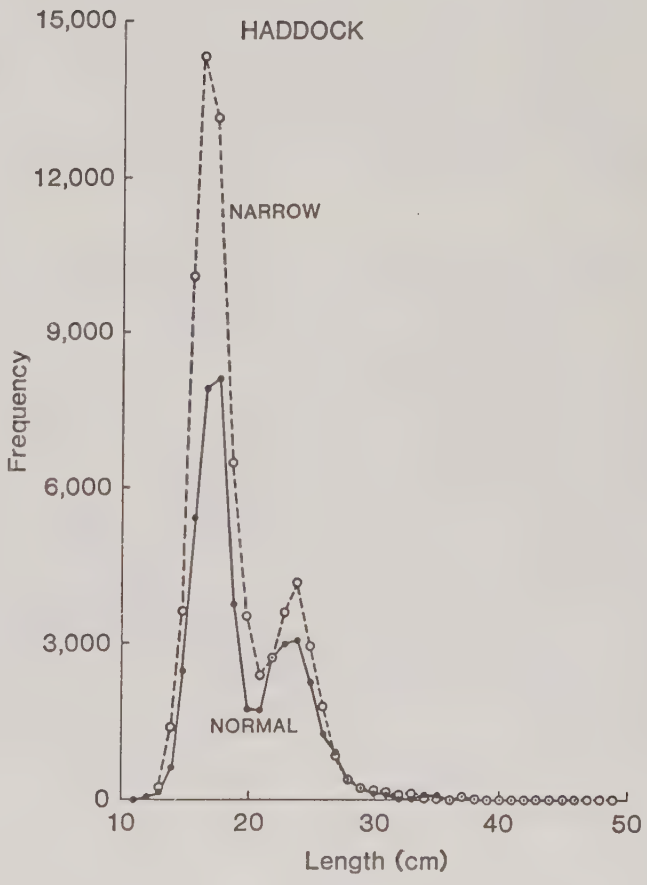


Figure 11. Haddock length/frequency distribution for normal and narrow cod-ends.

The total number of fish caught in the cod-end and the cover is assumed to represent the population available for capture. The benefit is calculated as the number of fish smaller than 27 cm in the cover expressed as a percentage of the total population of fish smaller than 27 cm entering the cod-end mouth. The penalty is calculated as the number of fish of 27 cm and larger in the cover expressed as a percentage of the total population of fish of 27 cm and larger entering the cod-end mouth. The numbers of fish for all hauls for each design type are added together before calculating the percentages. A two sample t-test was performed on the individual haul values of each group to check whether there was a significant difference in the mean values at the 95% confidence level. The significance is indicated in Table II and discussed below.

Table II

A comparison of the benefits and penalties of using different designs of cod-end for haddock in the upper table and for whiting in the lower table

Haddock

Cod-end design	Mesh size mm	Benefit: % which are released of all fish less than 27 cm	Penalty: % which escape of all fish of 27 cm or more
Normal	81.4	57) P = 0.0025	1) P = 0.10
Narrow	78.7	78) **	11) Not significant
Long extension	83.4	27) P = 0.12)	4) P = 0.10)
Short extension	83.4	75) Not significant	11) Not significant

Whiting

Cod-end design	Mesh size mm	Benefit: % which are released of all fish less than 27 cm	Penalty: % which escape of all fish of 27 cm or more
Normal	87.3	59) P = 0.065	27) P = 0.048
Narrow	89.5	80) Not significant	53) *
Long extension	83.4	53) P = 0.0030)	27) P = 0.022)
Short extension	83.4	92) **	63) *

* $P < 0.05$ (significant at the 95% confidence level)
** $P < 0.01$ (significant at the 99% confidence level)

These values for all four designs are compared for haddock in the upper part of Table II. For the normal cod-end, 57% of all undersized fish escaped but this percentage was significantly increased to 78% when a narrow cod-end was used. The other differences in benefit and penalty for haddock are not statistically significant.

The lower part of Table II shows the values for whiting. There was no significant difference in percentage of small fish released from the narrow compared with the normal cod-end. There was however, a significant increase in the numbers of marketable fish which escaped, from 27% for the normal cod-end to 53% for the narrow. For the long and short extension there was a significant increase in the release of small fish but also in the escape of marketable fish. The difference in results for haddock and whiting may be caused by morphometric differences — whiting have a smaller girth than haddock of a given length (Margetts, 1957) — or behavioural differences during capture.

The small differences in mesh size between the normal and narrow cod-ends should be noted when comparing these results (Table II). If the narrow cod-end mesh size had been the same as the normal cod-end mesh size then it would be expected that the benefit would be less but the penalty would be greater but vice versa for whiting where the mesh size is larger in the narrow cod-end.

Total Catch Composition

A major feature of the catches on the two "Crystal River' cruises was that the more selective gears — the narrow cod-end in 1986 and the short extension in 1985 — caught proportionately more small fish than the standard cod ends with which they were being compared. The length frequency distributions for the total catch (cod-end and cover) showed differences between long and short extensions (Figs. 8 and 9) for whiting and haddock and between normal and narrow cod-ends (Fig. 10) for whiting. During the "Heather Sprig" cruise few large haddock were caught. The fish distribution (Fig. 11) again showed that a greater proportion of small fish were caught by the narrow cod-end although the difference was less marked than for the "Crystal River" cruises.

Table III compares the percentage of fish smaller than 27 cm in the total catch for the pairs of cod-end designs. These figures were obtained from data for all valid hauls grouped by design type. A two sample t-test was performed on the individual haul values for the two designs and the mean values were found to be significantly different at the 95% level in two of the four categories as indicated in Table III. In the normal and long extension cases fish smaller than 27 cm make up a much smaller percentage of the total catch. Also shown are similar percentages for the cover and cod-end. The haul records show no systematic change in fishing area, depth or time of haul which might explain the difference. It is, however, possible that the fish population changed coincidentally with the change in cod-ends, eg by migration of smaller fish into or out of the area. This is considered unlikely as, for example, in the haddock catches on "Crystal River" in 1985 the changeover to the new gear was made in less than three hours and the change in catch composition was very marked.

If the fish population does not change, then the results may be explained by variation in the selection taking place ahead of the cod-end and cover. The more open cod-end meshes of the narrow cod-end and the short extension may cause higher water flows ahead of the cod-end or a difference in geometry of the main body of the net. Such effects may reduce the ability of small fish to escape ahead of the cod-end in these designs even though their chance of escape in the cod-end itself is better.

Another possible reason for the anomaly in total catch composition may be the use of small mesh covers. Selection ahead of the cod-end may be changed by a cover, perhaps in different ways for different designs of cod-ends.

Table III

The percentage of fish by number less than 27 cm in length in the cover, cod-end and total catch for haddock and whiting for each of the cod-end designs. There were few haddock larger than 27 cm in the normal and narrow cod-ends

Haddock

Cod-end design	Ship/year	Mesh size(mm)	No. of hauls	% of fish less than 27 cm in:— Cover	Cod-end	Total catch	
Normal	"Heather Sprig" /1985	81.4	6	100	91	96	P = 0.18
Narrow	"Heather Sprig" /1985	78.7	6	100	89	97	Not significant
Long extension	"Crystal River" /1985	83.4	7	34	5	7	P = 0.0006
Short extension	"Crystal River" /1985	83.4	5	78	13	34	***

Whiting

Cod-end design	Ship/year	Mesh size(mm)	No. of hauls	% of fish less than 27 cm in:— Cover	Cod-end	Total catch	
Normal	"Crystal River" /1986	87.3	3	8	2	4	P = 0.047
Narrow	"Crystal River" /1986	89.5	6	16	5	12	*
Long extension	"Crystal River" /1985	83.4	5	33	14	20	P = 0.073
Short extension	"Crystal River" /1985	83.4	3	66	21	5	Not significant

* $P < 0.05$ (significant at the 95% confidence level)
*** $P < 0.001$ (significant at the 99.9% confidence level)

Conclusions

The two changes in gear design tested here — from normal to narrow cod-end and from long to short extension — resulted in an increase in the 50% length, and with the short extension a significant reduction in selection range as well.

The more selective designs released a greater proportion of the smaller fish (smaller than 27 cm) which entered the cod-end mouth. For haddock, reduction in the catch of marketable fish was not statistically significant. Hence there is little disadvantage to the fisherman in using either of these designs. For whiting the reduction in the catch of marketable fish was significant – up to 35% of the available fish.

The cod-end selection mechanism appears to be related to the mesh opening, which is dependent not only on mesh size but also on other features of gear design. More quantitative information is needed on the effect of gear design on mesh opening and hence selectivity. It might then be possible to construct cod-ends with specific selection characteristics which strike an acceptable balance between conservation and economic viability for particular fisheries.

There is a suggestion from the results that some selection by size takes place ahead of the cod-end and that this selection is affected by the design of the cod-end and extension. Further data are required to confirm this finding.

Acknowledgements

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